

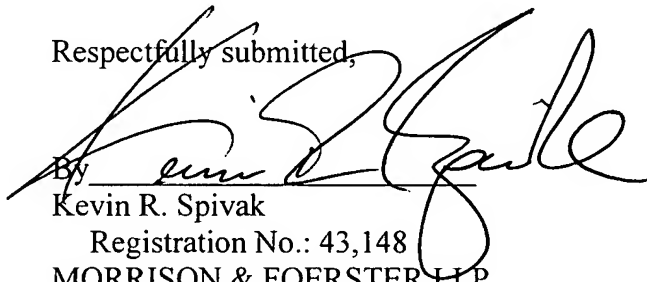
**REMARKS**

Amendments to the specification have been made and are submitted herewith in the attached Substitute Specification. A clean copy of the specification and a marked-up version showing the changes made are attached herewith. The claims and abstract have been amended in the attached Preliminary Amendment. All amendments have been made to place the application in proper U.S. format and to conform with proper grammatical and idiomatic English. None of the amendments herein are made for reasons related to patentability. No new matter has been added.

In the unlikely event that the transmittal letter is separated from this document and the Patent Office determines that an extension and/or other relief is required, applicant petitions for any required relief including extensions of time and authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to **Deposit Account No. 03-1952** referencing docket no. 449122078400. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

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Respectfully submitted,

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## HOME AGENT OPTIMIZATION FOR HANDLING MOBILE IP AND STATIC MPLS

CLAIM FOR PRIORITY

This application is a national stage of PCT/EP2002/007860, published in the German language on January 22, 2004, which was filed in the english language on July 15, 2002.

TECHNICAL FIELD OF THE INVENTION

The invention ~~concerns~~ relates to a method and an optimized home agent for transfer of IP datagrams over a path from a sender over a radio access network to a mobile host.

BACKGROUND OF THE INVENTION

The Mobile IP protocol is a concept to deal with user mobility issues for transport of IP related services. As a prerequisite the access network as well as the core network use IP as the network layer protocol and are capable to run, the mobile IP protocol in addition. The network architecture for mobile IPv4 includes home agents and foreign agents to build forwarding IP tunnels, when a mobile host moves out of the home network to attach to a different access point for requesting services from a network. The foreign agent represents the default router for a mobile host, if it is attached to an access point outside the home network. When a correspondent node sends packets to a mobile host currently registered at a different location, the home agent intercepts all packets for that host and reroutes them to the new location. The home agent's binding cache contains rerouting information for all mobile hosts currently attached to different access points. The care-

of-address specifies the mobile node's temporarily acquired host address after registering at a different location.

Using IP tunnels between home agent and foreign agent becomes inefficient, if the transport network already provides alternative tunneling mechanisms to interconnect various access points. The MPLS called label switching approach offers support for IP traffic engineering by introduction of virtual circuit switched services in connectionless IP based networks. Other benefits of MPLS include the establishment of virtual private networks and provision of traffic trunks with dedicated reserved bandwidth between two endpoints of a path (tunnel). When label switching is active, packet forwarding is based on a fixed label instead of an IP network address or prefix in the routing table. A label is attached by a label ingress router, which is the ingress router of the MPLS path. The label egress router represents the endpoint of a MPLS tunnel. Path setup requires a signaling protocol to agree on path attributes like labels to be used and requested bandwidth for the path etc. Examples are CR-LDP, RSVP-TE or BGP enhancements.

A network operator has to deal with convergence issues, if there is a strategy to offer mobile IP based services in a network, which has been engineered for MPLS. Functional components for mobile IP and MPLS may reside on the same network node in the situation described above. For example one network node may include home agent and label edge router functionality at the same time. The same applies to the mobile foreign agent. It is the challenge of equipment manufacturers

to provide integrated solutions for network components, in a way that mobile home /\_foreign agent are optimized for interworking with MPLS. It means that existing MPLS tunnels may be used for rerouting purposes in mobile IP instead of establishing a separate IP tunnel in parallel. This would allow the network operator to easily adapt mobility services to a MPLS infrastructure without the need for complex network resource management. There is no need to manage MPLS and IP tunnels in parallel.

Mobile IP and MPLS are emerging technologies. Though definition of concepts is quite stable there is no widespread usage so far. A simple approach is to deploy both technologies independently of each other and neglecting the possibilities of convergence. Thus MPLS paths would not be used to transport redirected packets to a mobile foreign agent. Instead MPLS tunnels for traffic engineering purposes and IP tunnels for mobile IP support would exist in parallel. However such a heterogeneous network would enlarge the effort for management of tunnels and represent a burden for consistent network engineering due to different technologies to be deployed in parallel.

A different approach is a loose coupling between MPLS and mobile IP. Home agent and label edge router would reside on the same network node without direct interaction between these components. The same applies to the foreign agent, which includes the label edge router functional components as well. Packets, which are destined for a mobile host, which is attached to a foreign access point would have to be

transported by means of an IP tunnel and a MPLS tunnel as well for the loose coupling. Home agent in this example first would have to encapsulate the native IP packet with an additional IP header, afterwards a label is attached to this packet by the label switching ingress router. As a benefit a pure MPLS network might be sufficient to forward packets to the foreign agent for the loose coupling approach. Nevertheless advantage of label switched paths is not used completely, since an additional IP tunnel is required.

#### SUMMARY OF THE INVENTION

~~An object of the~~ The invention is an efficient transport of mobile IP traffic. ~~This is achieved by the invention as set forth in the independent claims.~~

The invention described herein provides optimal usage of an existing static MPLS infrastructure while introducing IP mobility services. Static here means that label switched paths have been configured in advance based on mechanisms like traffic engineering. Primarily the focus is on a single administrative domain, where a network operator controls all network nodes, which are involved in mobility issues. Though the mechanism is not restricted to a single network domain. With the ~~introduced concept~~ invention, full advantage of an existing MPLS network can be gained for mobile IP forwarding. It is assumed that by means of traffic engineering a mesh of label switched paths has been established, which can be used for redirecting packets between any pair of mobile home agents and foreign agents in the current administrative domain. For the purpose of mobile IP no additional label switched paths

have to be created or modified. As well no IP tunnels are required between a home agent and a foreign agent. The solution for convergence proposes an optimisation of mobile home / foreign agents by efficiently incorporating label edge router functionality. A tight coupling between MPLS and mobile IP is achieved. No changes for existing protocols like mobile IP or label distribution protocol are required. Efficient usage of preestablished label switched paths for the transport of redirected packets between mobility agents requires traffic engineering for mobility. In that context it is necessary to gain knowledge about behaviour of mobile users, i.e frequency of leaving home networks, services to be requested at foreign access points etc.

The mechanism described for convergence between MPLS and mobile IP may be extended to different administrative domains. Macro mobility describes the situation, where a mobile user might attach to an access point, which is controlled by a different administrative authority in a geographically distinct area. Mobile IP forwarding and MPLS paths between separate domains may be enabled if service level agreements are established between adjacent network domains.

Advantageous features of the invention are:

- A modified home agent, which includes label edge router capability. Packet forwarding to any mobile host in a visited network is done exclusively by means of label switched paths, which interconnect mobility home and foreign agents. Thus for new mobility bindings in the home agent no creation or modification of label switched paths is required.

- An extended algorithm for mobility forwarding in home agent: If the mobile binding cache contains an entry, which corresponds to the destination address of an incoming packet, the home agent tries to map this care-of-address of the mobile node to a subnetwork address of the list of potential visited subnetworks. After the correct visited subnetwork has been identified the home agent is responsible to determine the proper label switched path for packet forwarding. Each subnetwork is associated with a label and the correct egress interface to use at the home agent.

- Usage of multipurpose label switched paths: These paths are not dedicated for mobile IP and therefore may transport packets for any other purpose as well.

- A list of potential visited subnetworks in the operators network domain. This list is maintained by each home agent in the network domain and configured by means of network administration principles. The list is required to enable mapping of the mobile nodes care of addresses to a visited subnetwork.

- An aggregated FTN table (Forwarding equivalence class To Next hop label forwarding entry): Generally for MPLS label switching the ingress router maintains this table for determining the necessary label and interface to use for a specific destination address. The home agent maintains this table with a single entry for each potential visited subnetwork, instead of an individual entry for each mobility

binding. Thus ~~all~~ mobile hosts attached to the same visited subnetwork correspond to one and the same entry in FTN table, which introduces scalability for the combined MPLS / mobility approach.

- A network with preconfigured statically administrated label switched paths. No paths have to be created or modified for the purpose of mobility handover. As a consequence signaling load in the network is reduced and handover delay is independent of setup time for label switched paths. These paths should provide enough bandwidth capacity to enable successful handover of mobile users almost anytime. Thus traffic engineering becomes a major issue for mobile IP with statically managed label switched paths.

- A foreign agent, where the functional entities of mobile IP and MPLS are co-located, but not correlated. Thus the label egress router component runs in parallel on the same host.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages of the invention are apparent from the following description of an example of the invention illustrated in figure 1.

Figure 1 shows a block diagram of an IP network.

#### DETAILED DESCRIPTION OF THE INVENTION

Three mobile stations MS 1, 2, 3 use some wireless link layer technology to connect to an IP based radio access network 4. Correspondent base stations BS 5, 6 , 7 terminate the radio



interface. The radio access network provides mobility support and uses label switched paths LSP 37, 62 for internal transport as already described for this invention.

Connectivity to transport networks 14 is achieved via border routers BR 8, 9, which separate the administrative domains. In this example all three mobile stations 1, 2, 3 are located in the same home network 4 - they get access by the same edge router, which includes the home agent (15) functional component at the same time. MS 2 and MS 3 currently moved to different access points (BS 6,7) and attach to the network through foreign agents FA 11 and FA 12 respectively. Two LSP's 37, 62 are illustrated for label switching between home agent HA 15 and foreign agents FA 11, 12. A correspondent node CN 13 typically located at any access point beyond the local network 4 should send data to ~~all~~ three mobile stations 1, 2, 3. For packets destined for MS 1 no entry in the binding cache (in 15) is available, thus packets are directly forwarded to MS 1. Now CN 13 sends data to MS 2. Home agent HA 15 includes a binding for MS 2 with care-of-address 137.21.16.5. From a configured subsystem list, the home agent is aware that MS 2 is currently reachable through subnetwork 137.21.16.0. Finally correspondent entry in FTN table for that subnetwork indicates that home agent needs to code "label 37" on its interface eth0 to forward the packet to the proper label switched path 37. Since LSPs are unidirectional they have to be originated at the HA and terminated at the FA. The illustration includes a further example for MS 3, which is attached to a different access point BS 7, where yet another label switched path (LSP

62) is used to forward packets to the correct destination (via FA12, BS7 to MS 3).

~~Claims~~ What is claimed is: